2014 DOE SSL R&D Workshop

Planning for Action

Fred Welsh
Radcliffe Advisors, Inc

SSL Multi-Year Program Plan

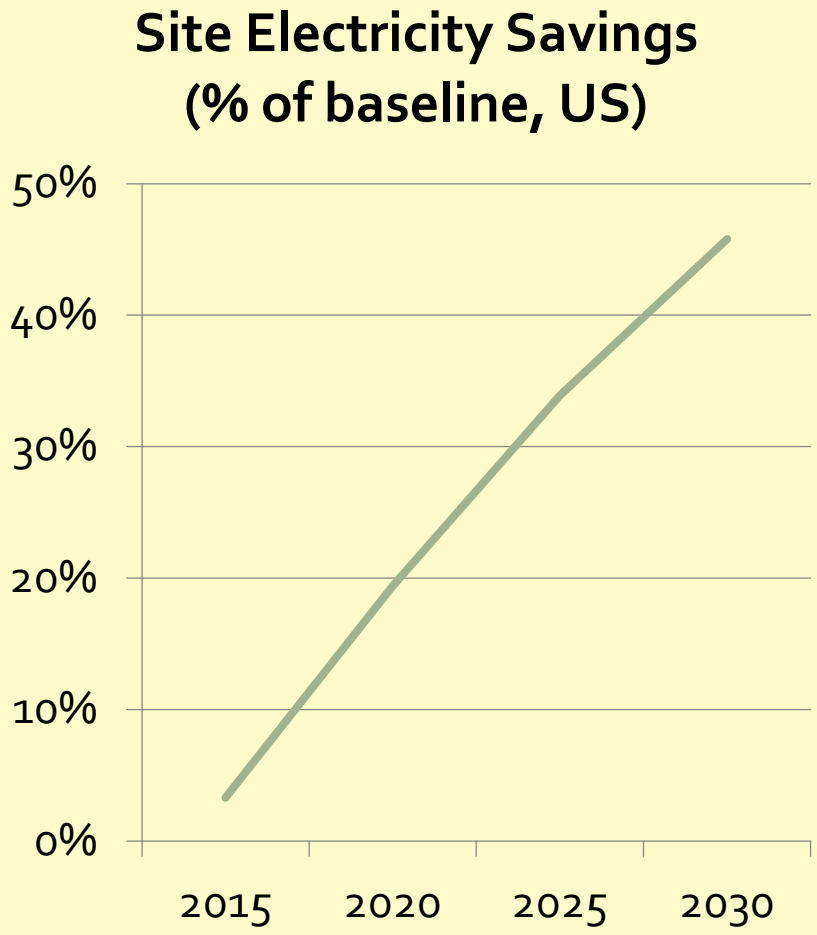
Three Key Elements:

- Set Goals
- Define Work
- Track Progress

The Goal of Energy Savings

- Energy savings for lighting is the overarching goal of the SSL program
  - Requires efficient lights
  - Requires widespread adoption

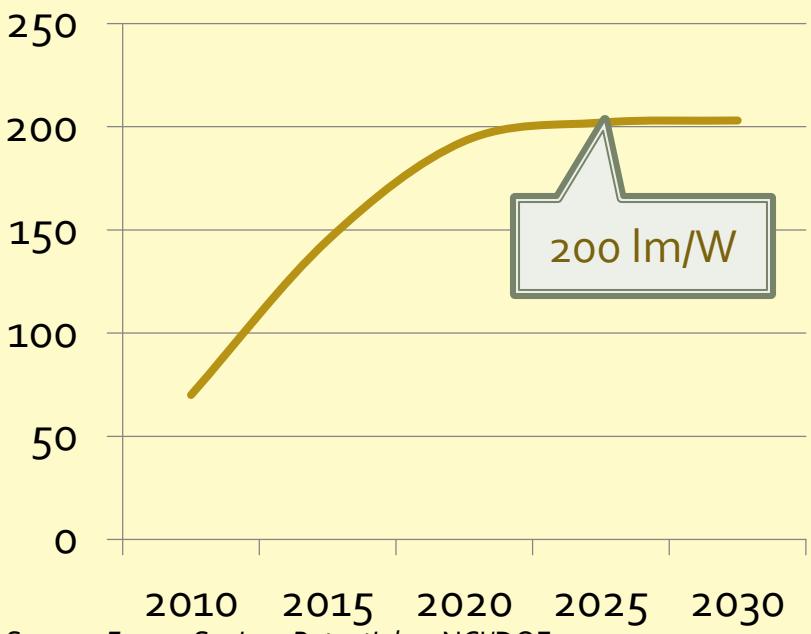
Source: *Energy Savings Potential of Solid-State Lighting in General Illumination Applications*, Navigant Consulting, Inc. for DOE, Jan 2012.



What Will It Take?

EFFICIENT LIGHTING

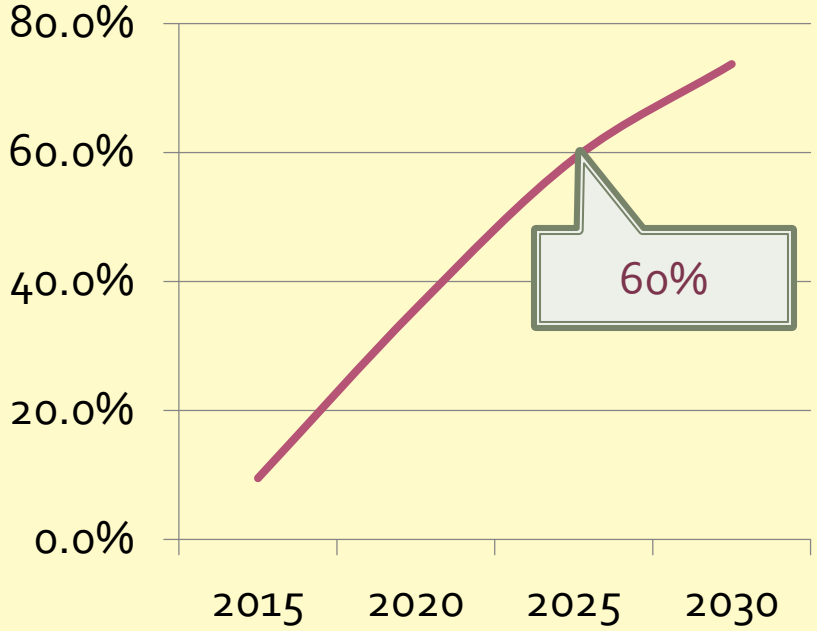
Luminaire Efficacy (lumen/Watt)



Source: *Energy Savings Potential* …, NCI/DOE

WIDESPREAD ADOPTION (US)

LED Market Share (% lm-hr)



Behind Efficiency and Adoption

EFFICIENCY

- Source efficacy is not the end of the story
  - Luminaire efficiency includes drivers, optics, and so on
    - Bulb-luminaire is the old way
    - Role of integrated lights?
- Efficient Deployment
  - Ambient vs task partitioning?
  - Room or building systems?
  - Built-in lighting?

ADOPTION

- Cost is only one factor
  - Old paradigm, good for bulbs, maybe, but…
  - Exclusive cost focus leads to commoditization
- Features sell, too
  - Control can mean stability as well as variability
  - Control includes light pattern, color, brightness
    - How can it be exploited?

Light Bulbs are Commodities

- Commoditization means virtually no differentiation other than cost. Lack of innovation eventually leads to commoditization.
- Added value means product differentiation, profitability and jobs – a thriving enterprise. R&D supports innovation; innovation drives value.

Choose your vision

Finding Value

- Color?
- Dimming and Controls?
- Light Profile?
- Light Output?
- Appearance?
- Deployment?
- What else?

Goals to Milestones to Tasks

- Re-think the milestones
- Will they get us to the larger goal?
- Look farther into the future

- Focus R&D resources on barriers
  - *Technical* barriers to adoption
  - Barriers to reaching 200 lm/W luminaire efficacy
- Identify priority tasks for the near term
  - Add tasks to add value?

LED Milestones

Will these targets increase total energy savings? Value?

Year	Target
FY12	Luminaire: 100 lm/W; ~1000 lumens; CCT 3500K, 80 CRI, 50,000hrs to L_{70}
FY15	LED package: < $2/klm (cool white); ~$2.2/klm (warm white)
FY17	Luminaire: >3500 lumens (neutral white); <$100, >150lm/W
FY20	Luminaire: 200 lm/W Smart troffer with integral controls, <$85

Source: 2013 MYPP

LED package results at 35A/cm2 current density, 25C.

OLED Milestones

Will these targets increase energy savings? Value?

Year	Target
FY12	Laboratory panel: 200 lm/panel; > 70 lm/W; > 10,000 hrs
FY15	Commercial panel: >100 lm/W; <$50/klm (price); 20K hrs
FY18	Luminaire: 100 lm/W
FY20	Luminaire: price<$50/klm

Source: 2013 MYPP

Panel is min. 200cm^{2},

Defining Work

Given the goals,

- What are the technological barriers?
- What needs to be done to overcome them?
- What are the specific tasks and priorities?
- What's the timetable?

Some Key Barriers

LED TECHNOLOGY

- Control over the spectrum
- Understanding of color perception and needs
- Luminaire reliability
- Lack of efficient sources for all colors
- Narrowband red phosphors
- Inflexible packaging
- LED-specific controls

OLED TECHNOLOGY

- High cost of fabrication
- Light extraction
- Stability of blue emitters
- Understanding of degradation processes
- Practical substrates and electrodes
- Scaling up to useful sizes
- High performance encapsulation

Recommended Tasks– LED Core

Preliminary Recommended LED Core Tasks	
A 1.2	Emitter Materials Research
A 1.3	Down Converters
A 2.2	Novel LED Emitter Architectures
A 8.1	Light Quality Research

Recommended Tasks– LED Prod Dev.

Preliminary Recommended LED Product Development Tasks	
B 1.1	Substrate Development
B 3.6	Package Architecture
B 4.2	Epitaxial Growth
B 6.3	System Reliability and Lifetime
B 6.4	Novel LED Luminaire systems
B 7.4	Electronic Subsystems Research

Recommended Tasks– OLED Core

Preliminary Recommended OLED Core Tasks	
C 1.2	Stable White Devices
C 3.1	Fabrication Technology Research
C 6.3	Novel Light Extraction Approaches

Recommended Tasks–OLED Prod. Dev.

Preliminary Recommended OLED Product Development Tasks	
D 2.1	Substrate Materials
D 2.2	Low-Cost Electrodes
D 6.3	Panel Light Extraction and Utilization

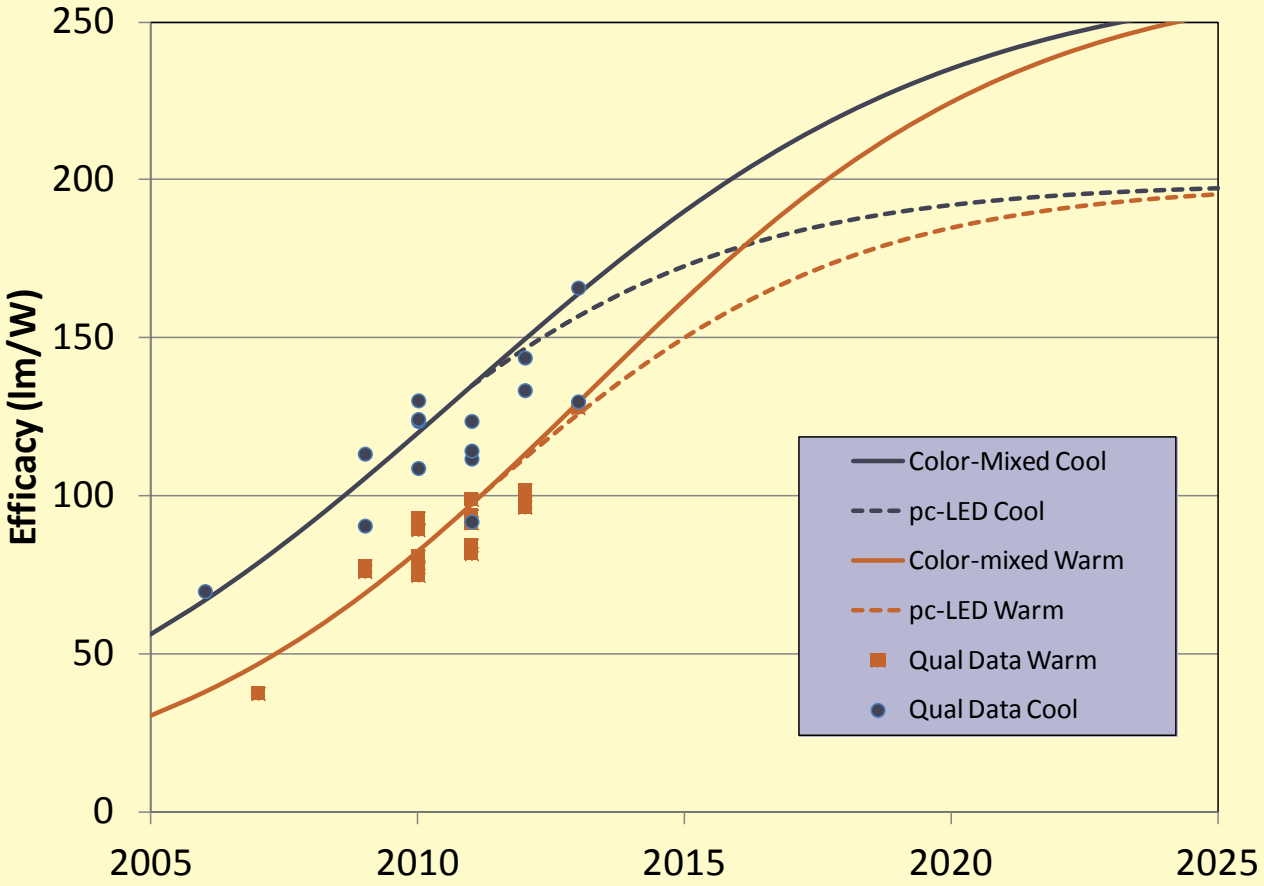
Tracking Progress

General Goals

- Luminaire efficacy ~200 lm/W
  - Source efficacies higher
- 60% of light from SSL technology
- Long life products, ~ 25K hrs or more
- Competitive price for value

How can we best track progress?

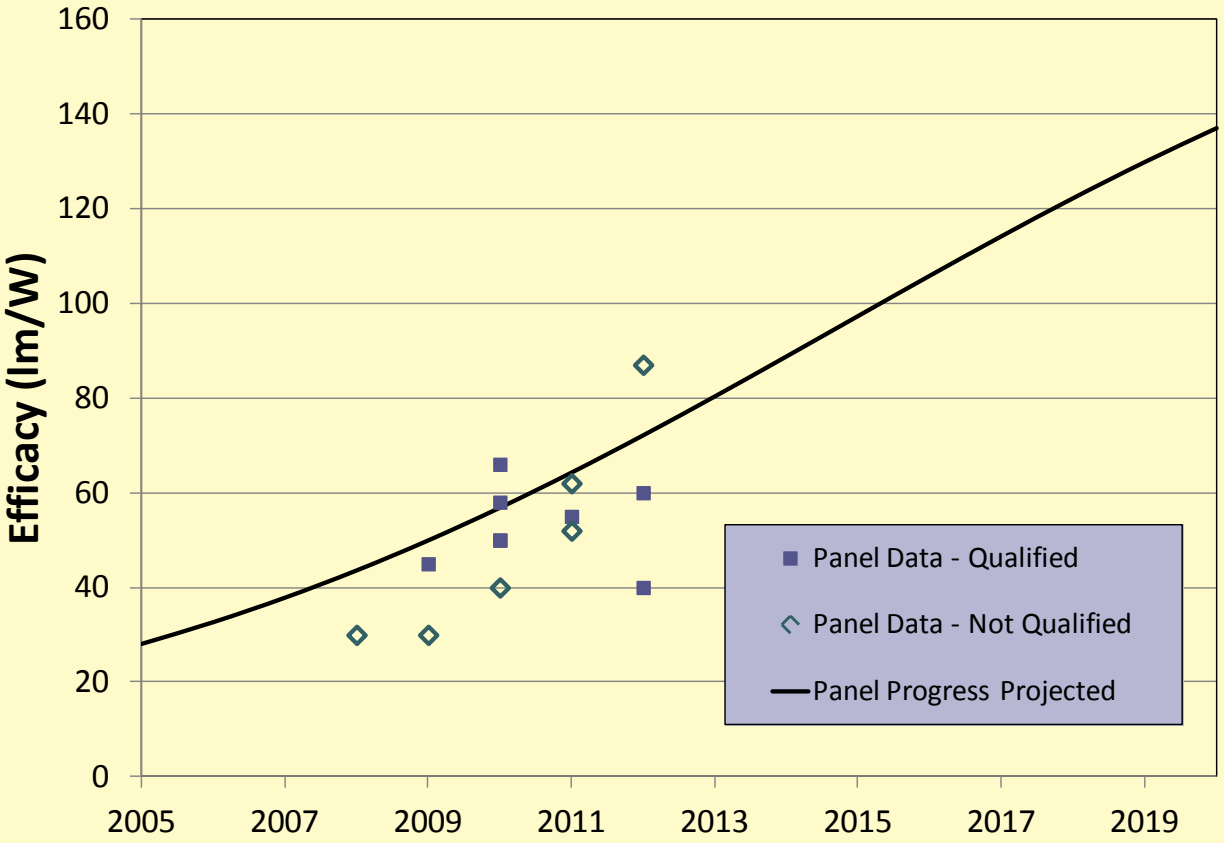
LED Package Efficacy



Referenced to 35A/cm²

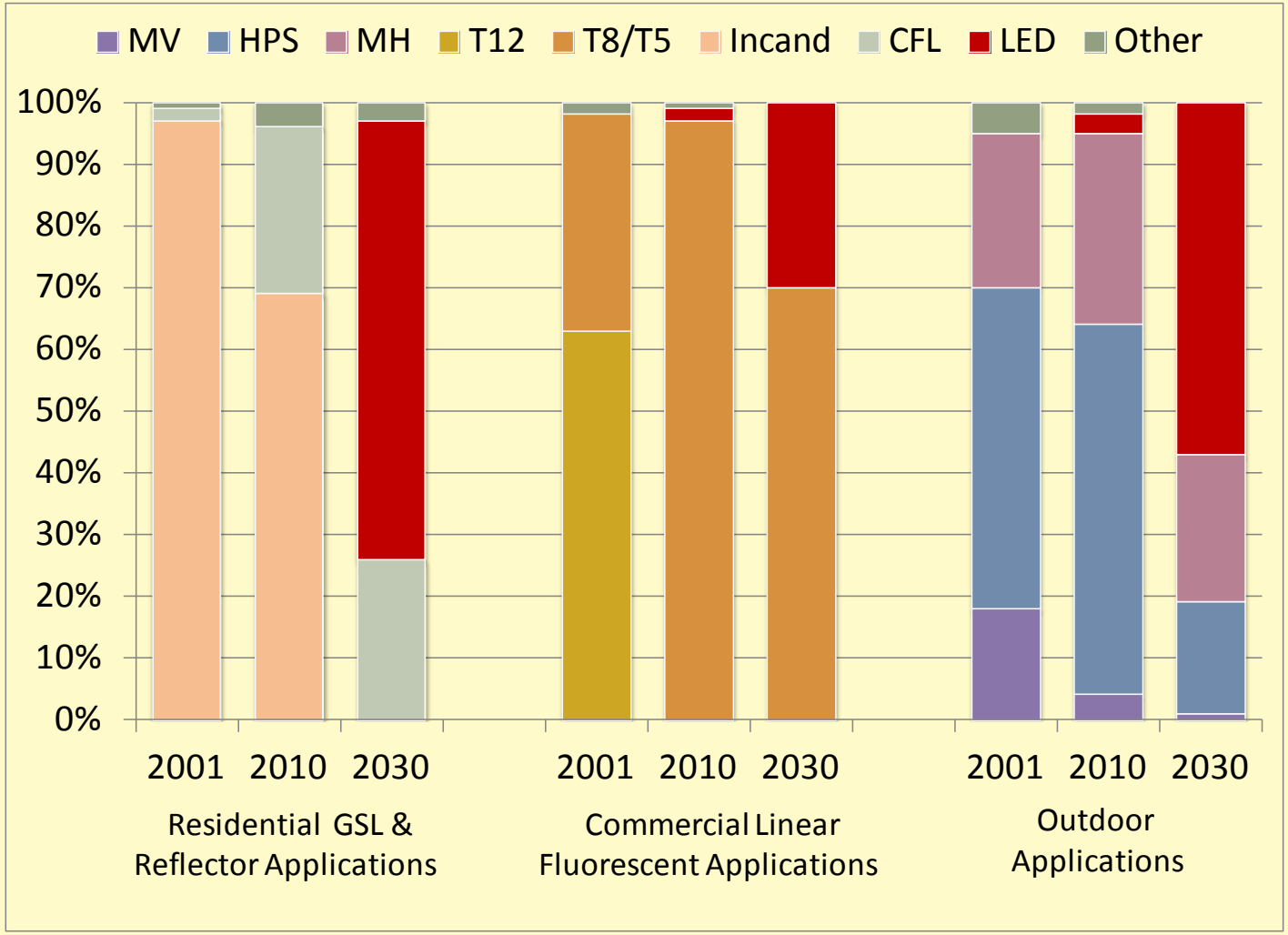
Source: 2013 MYPP

OLED Efficacy



Source: 2013 MYPP

Progress towards Adoption



2013 MYPP

Ideas Needed for the MYPP

- We've focused mostly on efficacy, lumens/Watt
  - First the efficacy of the packaged LED
  - Now more on luminaire efficacy
- How do we track progress on adding value?
  - What would be useful metrics for:
    - Color?
    - Controls?
    - Lifetime?
    - Other features…
- How about adoption in terms of generated light?
- What would be useful to you?

Nuts and Bolts

LED TOPIC TABLES

- Choose your table, sign in
- Choose a scribe
- Bin the overall list of tasks into relative priorities
- Turn to your task
  - Why is it important?
  - What changes should be made in the task table?
- Use the PPT to prepare a summary

OLED FORUM

- Review OLED goals
- Review list of recommended tasks; nominate additions for discussion
- Bin amended list into relative priorities
- Recommend changes to urgent or important tasks

Binning the Tasks

Urgent	Important	Desirable
A.2.2 Novel Emitter Architectures		A.1.2 Emitter Materials Research A.1.3 Down Converters A.8.1 Light Quality Research B.1.1 Substrate Development B.3.6 Package Architecture B.6.3 System Reliability and Lifetime B.6.4 Novel LED Luminaire Systems B.7.3 Smart Controls B.7.4 Electronic Subsystems Research

Cut… and Paste

Getting It Done

- DOE needs your inputs!
  - Use the cards
  - Participate in the LED Topic Tables or OLED Forum
  - Tell us what should be changed